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Experimental Emulsified Diesel and Benzen Investigation

Sayel M. Fayyad, Suleiman Abu-Ein, Ghazi Al-Marahleh, Waleed Al-Momani
Muntaser Al-Momani, Zaid Abulghanam, Omar Badran and Taiseer Abu-Rahmah
Department of Mechanical Engineering, Faculty of Engineering Technology,
P.O. Box 15008, Al Balqa Applied University, Amman, Jordan

Abstract: This study presents an experimental investigation of emulsified fuels as an operating material for vehicle engines. Water in fuel blends is still relatively unknown and unaccepted by the majority of people. Introducing water into the combustion chamber has been around for more than one time, through water injection systems and emulsification of water into fuel. Adding water to fules will reduce bad emissions of the vehicles. It is found that brake power, engine power and also the engine torque have been improved with the emulsified fuels for both diesel and benzen till 25% water percentage addition.

Key words: Brake power, emissions, emulsions, engine, fuel blends, torque

INTRODUCTION

The dreaming of adding water to fuel began in 1931 by Joseph Vance, up of (40-60)% of water was added to the liquid hydrocarbons fuel, and achieved the theory in 1991 on hand Rudolf W.Gunnremans - Water emulsified in fuel –where the mixing procedure and the water content in the emulsified fuel were modified (Gunnerman and Russel, 2003).

In 1931 Joseph Vance suggested application related to process for making liquid fuel use in heating apparatus or combustion engines. Emulsified fuel is defined as adding water to the fuel then mixed together by adding specific additives as shown in Fig. 1. Many researches focused in using water with fuel as a emulsified fuel, Yatsufusa *et al*. (2009), studied the effect of water addition to fuel by emulsification on combustion and emission characteristics using air-assisted fuel atomizing burner. Water addition elongates the combustible range to higher fuel equivalence ratio side by reduction of PM emission. The water addition also reduces NOx emission drastically. Although the reduction of NOx is caused by the reduction of locally high temperature region, the reduction of global flame temperature is not significant, thus thermal penalty by adding water is negligible. Water addition is also effective to reduce PM emission especially in higher fuel equivalence ratio (Yatsufusa *et al*., 2009).

Alahmer *et al*. (2009), the performance of an engine together with its effect on environment were tested when engine was powered by both pure diesel and emulsified fuel with various quantities of water content in the diesel fuel. The amount of water quantities added ranged between 5 and 30% by volume. The engine speed during the experimental work was within the range from 1000 to 3000 rpm. While producing similar or greater thermal efficiency and improved NOx emission outcomes use of the emulsion also results in an increase in brake specific fuel consumption. It was also found that, at high amount of water addition, the nitrogen oxide decreases. Also, in general, the diesel emulsion fuel emitted an amount of CO2 higher than that of pure diesel (Alahmer *et al*., 2009).

Jae *et al*. (2000), combustion characteristics of the emulsified diesel fuels were investigated in a Rapid Compression and Expansion Machine -RCE-. Among the test cases the 40 W/O fuel injected at BTDC 20° has shown the best performance with respect to the efficiency and NOx and soot emissions. The pressure trace of the 40 W/O fuel is characterized by a longer ignition delay and a lower rate of pressure rise in premixed combustion. High-speed photographs show reduced flame luminosity and lower flame temperature with the increasing W/O ratio, (Jae *et al*., 2000). Micro-explosions of emulsified fuel droplets, which affect the local shape and brightness of the flame, are identified in magnified flame images (Harbach and Agosta, 1991; Abu-zaid, 2004a).

The present work aims to conducting the usage of different percent of emulsified fuels experimentally in order to find the optimal mixture of such emulsion, and measuring its effects on the operation of the engine.

MATRIALS AND METHODS

Different percentages of water were added to both benzen and diesel fules and then injected to an internal

Corresponding Author: Sayel M. Fayyad, Department of Mechanical Engineering, Faculty of Engineering Technology, P.O. Box 15008, Al Balqa Applied University, Amman, Jordan

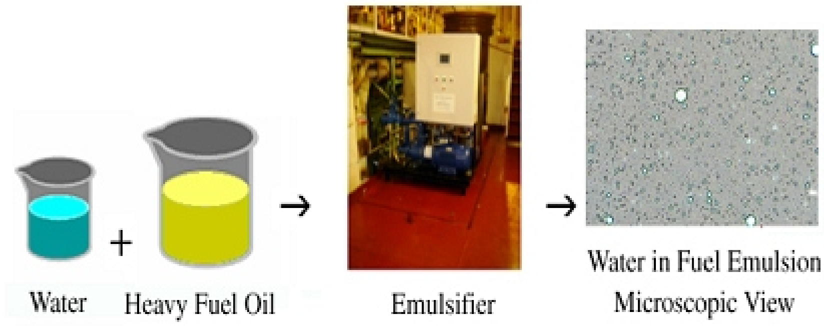

Fig. 1: Emulsion contents

combustion engine, the experiments were inducted in 2007, at the Faculty of Engineering Technology (BAU) labroteries and at University of Jordan labroteries - Amman-Jordan.

Experimental work: The water addition ranges between 0-30% and the maximum water content arrives to 40%. The mixing created by an homogenizer device which water particles become micro-explode due to the discrepancy of the boiling point between the diesel and the water (boiling point of water 100°C, boiling point of the diesel 185°C) so that the emulsion fuel drops divided into finer particles and its leads to increasing the volatility of the fuel and that affect clearly on the combustion efficiency. The mixture is immediately injected and atomized within the engine's combustion chamber. The heat inside the combustion chamber causes the water droplets to vaporize into steam. Creating the steam uses up energy and lowers the peak combustion temperature. At the same time, when the water droplets vaporize, they produce "micro-explosions" inside the surrounding fuel droplets. The micro-explosions expose more of the fuel's surface area to the air, which increases combustion. Just as a block of ice melts(i.e., releases energy) faster when it's shattered into small chips the fuel burns (releases energy) more completely after it has been shattered by the micro-explosions also release the water's two elements - hydrogen and oxygen. The additional oxygen inhibits the formation of the compound called PAH (Polycyclic Aromatic Hydrocarbons). During combustion, PAH is not burned completely; the unburned PAH becomes particulate matter (PM). By reducing the amount of PAH, the additional oxygen also reduces the production of PM. The reduction is on the order of two to three times the water content of the water-in-fuel emulsion (i.e., a 20% water content would reduce PAH- generated particulate matter by 40 to 60%). The color of the regular fuel is changed to a white milky color that it's guided to changes the regular fuel properties, this color makes many questions and suggestion on the consumers, the white milky color related to the surfactant addition (Abu-zaid, 2004b; Gunnerman and Russel, 2003; Tsukahara and Yoshimoto, 1992).

Water diesel and benzene emulsion fuel contents: The function of emulsifier or "surfactant" as commonly named is mainly to stabilize water in diesel mixture, which can't be maintained by natural mixing of diesel with water, because of their different densities and forces of surface tension exist at the separation zone of the two substances, surfactant reduce surface tension forces, so that permit two different densities liquids to mix with stable chemical composition, that aid the formation and retention of emulsion. Chemical composition of surfactant shows that it consists of two parts Hydrophilic and Hydrophobic, hydrophilic moiety has tendency to react with water, on the other hand, hydrophobic moiety has tendency to react with oil. Surfactant has many types, forms, and purposes it divided into two main classifications: organic and non-organic surfactants. It can be liquid (with high density) or powder, or other forms, each form used in specific purposes, and it covers wide range of industrial uses, it used in nutrition industries, medical industries, and chemical industries, especially in cosmetics and cleaning products industries (Harbach and Agosta, 1991).

Many tests carried out on the proposed emulsion to reach the suitable long-life emulsion and use it in this study. In this study the test of stability applied on two 600 ml samples both have 75% diesel, 25% water 2.5% emulsifier composition was added all based on total volume of emulsion 1st sample contain tape water (named sample A), while in the second sample used dematerialized water (named sample B), to investigate which one is more effective emulsion stability. Dematerialized water as shown in Fig. 2, and results were seen to be more efficient, and produce, longer-life emulsions are used more than tape water emulsions and indicate good stability appearance and performance when be tested on diesel engine many advanced tests must be

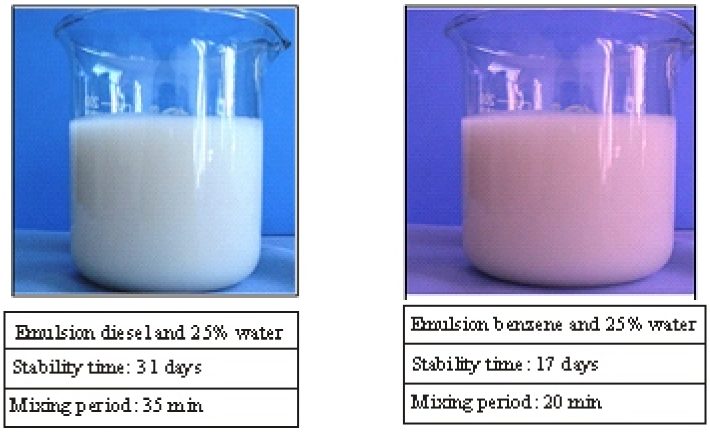

Fig. 2: Stability tests on water diesel emulsion fuel

run out to explain this result but simply salts being dissolved in tape water effect negatively on surfactant function and so on stability time, as a result using dematerialized water in emulsions is recommended. These samples (25% water content) were chosen arbitrarily; emulsion samples that contain less amount of water may be more stable or have longer stability time (Ganesson and Ramesh, 2002; Harbach and Agosta, 1991).

RESULTS AND DISCUSSION

In this work water in diesel emulsion was tested in (CI) to investigate the effect of water emulsification on the most two important consideration of any engine: Performance of the engine, and to compare the efficiency of the engine of the emulsion and the pure fuel (pure diesel). Performance analysis was studied on a single cylinder, direct injection engine. Performance analysis includes torque, brake power, and thermal efficiency. Several diesels (CI) engine tested using water in the (diesel) emulsion has been conducted in this study; five samples (blends) were tested: pure diesel, diesel surfactant + 10, 15, 20, 25% water by volume. For each run the engine was started on pure diesel and then switched to the test sample. All tests were run out at constant load, variable engine speed operating at 1000-1500 rpm. The performance analysis gives a high knowledgment on feasibility of used water-diesel emulsion fuel and discovers the advantages and disadvantages of this new fuel product. The effect of water addition on the form of emulsion on the engine output torque is shown in Fig. 3. The torque is a function of engine speed, at low speed, torque increase as engine speed increase, reaches a maximum value, then the speed increases. Also as shown in Fig. 3 the percentage of

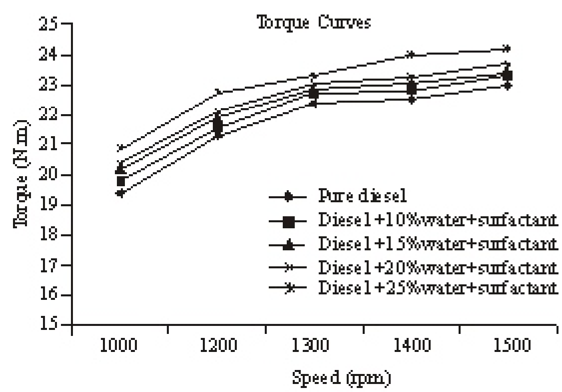

Fig. 3: Engine torque versus engine speed using water diesel emulsion

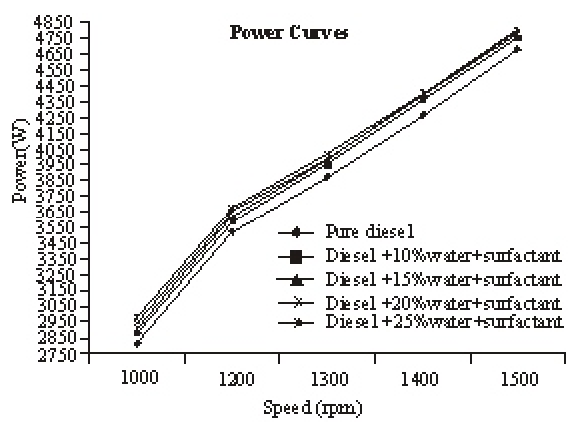

Fig. 4: Engine power output versus engine speed using water diesel emulsion

water in the emulsion increases, the torque produced will increase. This may be attributed to the additional force on top of piston provided by the pressure exerted by the steam. When the charge is fired in the cylinder, the water would turn to high-pressure steam. In addition, the higher viscosity of the emulsified fuel than that of the base fuel (diesel) and the presence of water promote a finer, cloud like atomization of the emulsified mixture during injection. Result in improving efficiency significantly.

The effect of the emulsion on the engine power is shown in Fig. 4, the power increases as engine speed increases, and decreases at higher speeds, this is because friction losses increase with speed and become the dominant factor at very high speed. Also Fig. 4 shows that the power increases slightly as the water percentage increases. The increase in power output for the emulsion is because water in the emulsion influences combustion of the fuel. It was found that the introduction of water in diesel prolongs the ignition delay. The ignition delay period is when the fuel that has been injected into the cylinder is undergoing chemical and physical preparation for combustion. Thus, the emulsion fuel requires less compression (negative) work than the diesel due to the longer ignition delay during the compression stroke. This helps to reach a higher peak pressure after TDC to produce more power output during the expansion stroke. In addition, when the ignition delay increases, more diesels would be physically prepared (evaporation, mixing) for chemical reaction, which increases the amount of diesel burned and the rate of heat release in the premixed burning. This result enhances the combustion and improves the combustion efficiency.

Figure 5 shows that as the water percentage in the emulsion increases, the brake efficiency causes the BSFC will increase then the efficiency will increase, this is because as the percentage of water in the emulsion increases, a larger amount of diesel is displaced by an equal amount of water. This means that less diesel fuel is actually contained within each volume of the emulsion. It is clear from Fig. 5 that as the percentage of water of the emulsion increases, BSFC of diesel decreases. The minimum value occurs at a water percentage 25% by volume.

Water in benzene was tested in (SI) engine to investigate the effect of water emulsification on the most two important consideration of any engine: Performance of the engine, and to compare the efficiency of the engine of the emulsion and the pure fuel (pure benzene). Performance analyses were studied on a single cylinder, direct injection engine. Performance analysis includes torque, brake power, and thermal efficiency. Several benzene engine tested using water in the benzene, emulsion have been conducted in this study; four samples (blends) were tested: pure benzene, benzene fuel +surfactant + 5, 10, 15% water by volume. For each run the engine was started on pure benzene and then switched to the test sample. All tests were run out at constant load, variable engine speed operating at 1000-1500 rpm. The

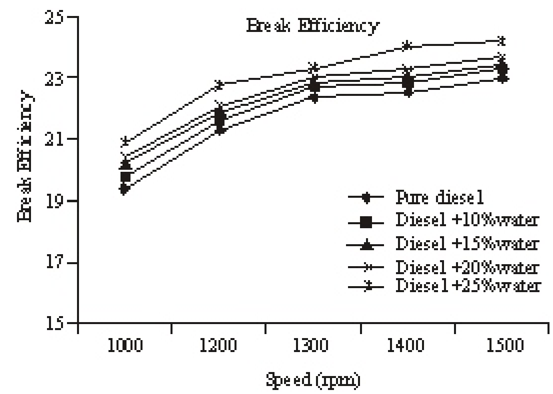

Fig. 5: Engine brake efficiency versus engine speed using water diesel emulsion

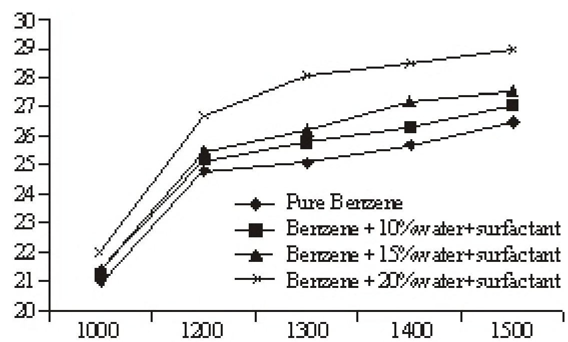

Fig. 6: Engine torque versus engine speed using water benzene emulsion

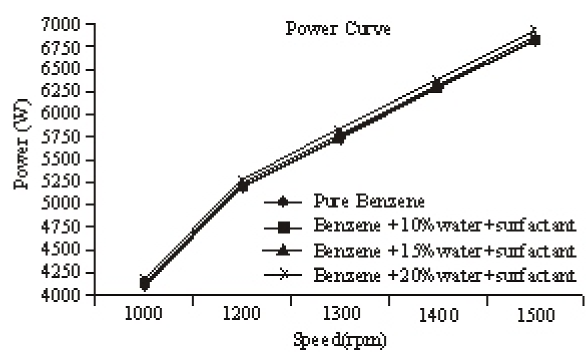

Fig. 7: Engine power output versus engine speed using water diesel emulsion

performance analysis gives a high knowledgment on feasibility of used water benzene emulsion fuel and discovers the advantages and disadvantages of this new fuel product. The results for burning the emulsion fuel and regular benzene can show below. The effect of water addition on the form of emulsion on the engine output torque is shown in Fig. 6. The torque is a function of engine speed, at low speed, torque increase as engine speed increase, reaches a maximum value, then the speed

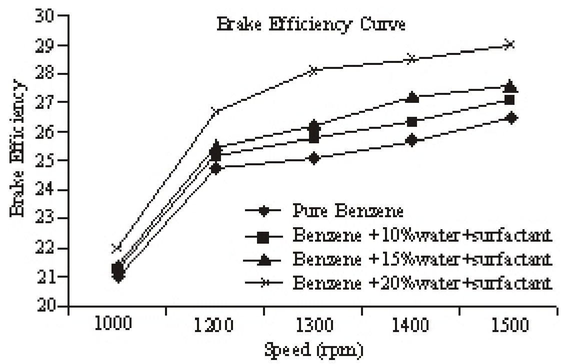

Fig. 8: Engine brake efficiency versus engine speed using water diesel emulsion

decrease. As shown in Fig. 6 the percentage of water in the emulsion increases, the torque produced will increase. This may be attributed to the additional force on top of piston provided by the pressure exerted by the steam. In benzene the torque will decreases when the percentage of water up of 15% because the pressure in piston will increase that will effect to the cylinder and increase the (negative) work of the cylinder. In addition, the higher viscosity of the emulsified fuel than that of the base fuel (benzene) and the presence of water promote a finer, cloud like atomization of the emulsified mixture during injection. Result in improving efficiency significantly.

The effect of the emulsion on the engine power is shown in Fig. 7, the power increases as engine speed increases, and decreases at higher speeds, this is because friction losses increase with speed and become the dominant factor at very high speed and for the high pressure because the high density and viscosity in the emulsion contents, and the designing of the piston and cylinder can't maintain this effects. Figure 7 shows that the power increases slightly as the water percentage increases. The increase in power output for the emulsion is because water in the emulsion influences combustion of the fuel. It was found that the introduction of water in diesel prolongs the ignition delay. The ignition delay period is when the fuel that has been injected into the cylinder is undergoing chemical and physical preparation for combustion. Thus, the emulsion fuel requires less compression (negative) work than the diesel due to the longer ignition delay during the compression stroke. This helps to reach a higher peak pressure after TDC to produce more power output during the expansion stroke. In addition, when the ignition delay increases, more benzene would be physically prepared (evaporation, mixing) for chemical reaction, which increases the amount of benzene burned and the rate of heat release in the premixed burning. But in benzene emulsion when the emulsion is burned up of 15% containing water the engine is vibrated and becomes noisy because of the effect of high pressure in the cylinder in high speed.

Figure 8 shows that as the water percentage in the emulsion increases, the brake efficiency causes the BSFC will increase then the efficiency will increase, this is because as the percentage of water in the emulsion increases, a larger amount of benzene is displaced by an equal amount of water. This means that less benzene fuel is actually contained within each volume of the emulsion. It is clear from the Fig. 8 that as the percentage of water of the emulsion increases, efficiency sill increases. The minimum value occurs at a water percentage 15% by volume. The reduction in BSFC with water emulsified benzene may be attributed to formation of a finer spray due to rapid evaporation in the water, longer ignition delay results in more fuel burning in premixed combustion and suppression of thermal dissociation due to lower cylinder average temperature, and it caused high temperature in cylinder and engine. The evaporation and additional mass of water cause the cylinder average temperature to become lower as the water amount was increased (John, 1988; Obert, 1973; Sharma and Mathur, 1981).

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